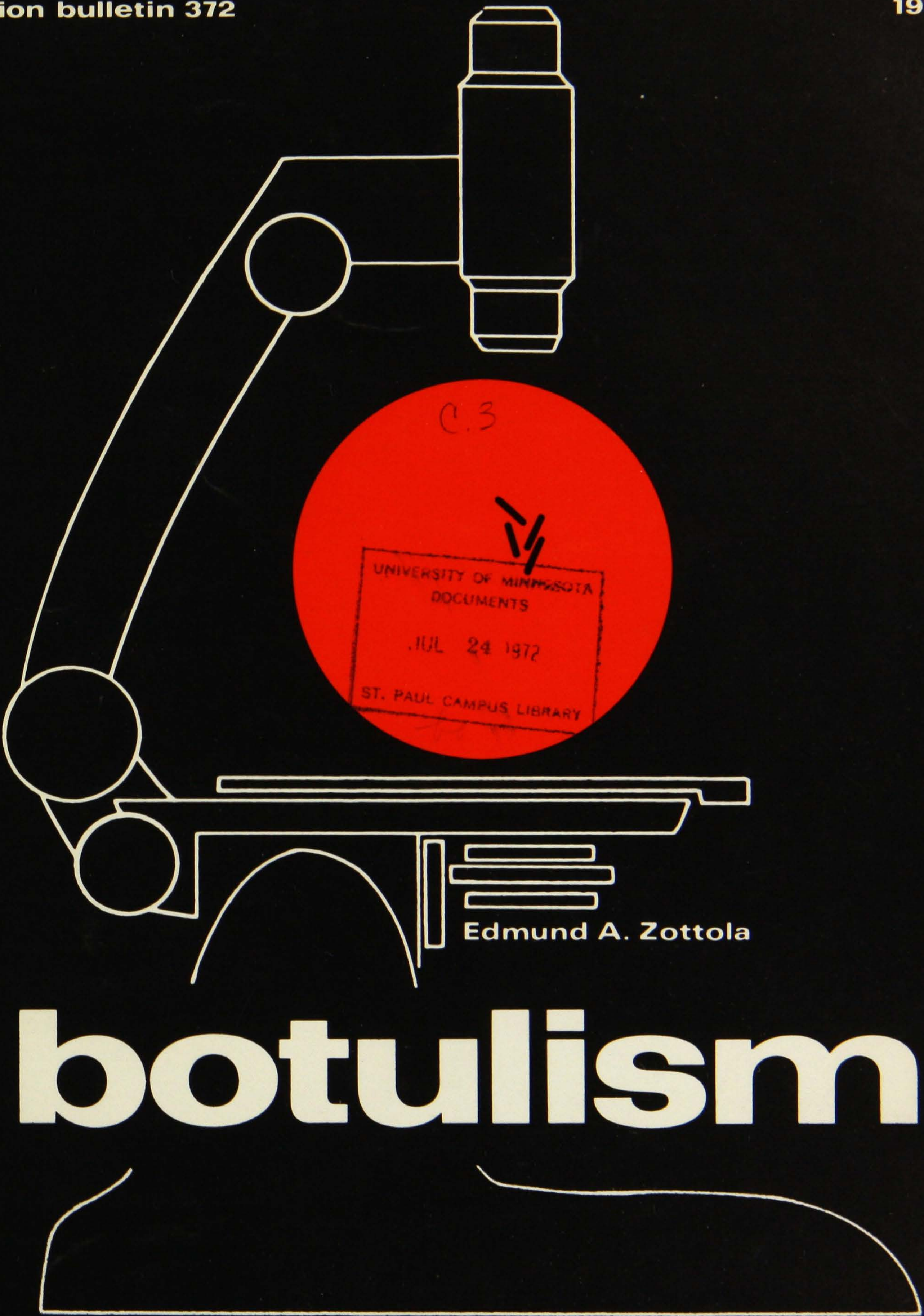
extension bulletin 372

1972



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botulism

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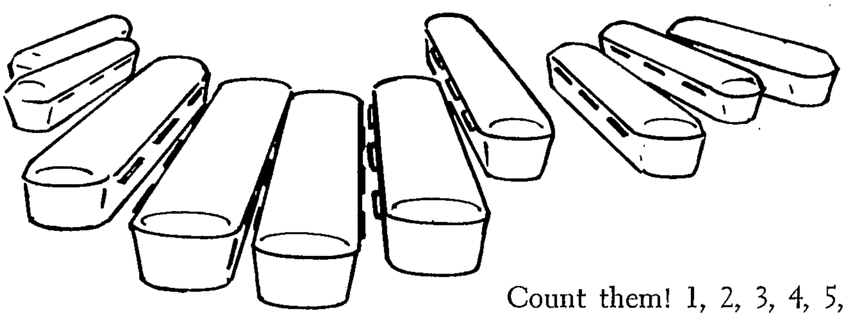


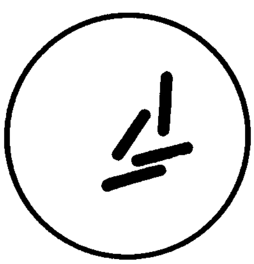
Count them! 1, 2, 3, 4, 5, 6, 7, 8, 9, 10! A morbid sight—10 dull gray caskets awaiting the funeral. An uncommon sight and an unnecessary one—an entire family wiped out by **botulism.** You say it's impossible and cannot happen—but it did and still does. This particular incident occurred in 1924 when an entire family died after consuming improperly processed home-canned string beans (1).

You say this is ancient history and cannot happen today. Perhaps, but in September 1971, five members of a family of seven became seriously ill with botulism after eating chili sauce prepared from home-canned peppers. One of the five died; the other four, although seriously ill, recovered (2). This particular incident was the 10th outbreak[1] of botulism reported in 1971 and involved the largest number of cases since 1965. Five of the outbreaks in 1971 were caused by home-canned food, one by commercially-canned food, the cause was not established for two other instances, and the remaining two outbreaks were due to wound infections. In 1970, there were six reported outbreaks of botulism affecting 13 persons. Of these 13, five died. In all six of these outbreaks, home-processed foods were involved (4).

Not all botulism outbreaks are caused by home-canned foods. A very small percentage of outbreaks are caused by commercially-canned foods. Since 1925, there have been four deaths attributed to botulism from commercially-canned foods, one in 1941, two in 1963, and one in 1971. This is a remarkable record for the commercial canning industry when you consider that during these 47 years (1925-1972), 775 billion cans of food were sold in this country.

Botulism almost always is associated with food that has been preserved in some way. Food preservation is defined as treatment of food by one process or another to prevent microbial destruction of the food before it can be utilized by man. There are various processes to preserve food. A detailed discussion of these techniques is beyond the scope of this publication, but it is necessary that several terms be defined.

Processed foods, in this text, means foods that have been preserved by a process other than canning. Canned foods are foods that have been heat-treated in a sealed container to achieve preservation. If these treatments are done by an individual in his home, they will be referred to as home canned or home preserved. If these precesses are carried out in a factory on a large scale, they will be called commercially canned or commercially processed.



Botulism is a food-borne disease caused by the micro-organism *Clostridium botulinum.* This illness is a true food intoxication or food poisoning. These bacteria produce a deadly toxin or poison when they grow in food. This poison is the most deadly one known to man. Scientists estimate that one cupful (8 ounces) of this purified poison would kill all the people on earth (6).

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[1] An "outbreak" is an occurrence of an illness that involves a number of individual "cases" or persons who become ill. Thus, the number of reported cases will always be greater than the number of reported outbreaks.

Clostridium botulinum is a rod-shaped bacteria that is found in soil all over the world. This micro-organism has the ability to form an entity called a *spore*.[2] In the spore form, it is very resistant to adverse conditions. For example, heat, chemical treatments, physical stress, and other environmental changes that normally will destroy vegetative[2] micro-organisms have little if any effect on spores. This characteristic is one reason why outbreaks of botulism are usually associated with home-canned, preserved, or processed foods. The process food undergoes may not be sufficient to destroy the spores of these bacteria. Then, during subsequent storage of the food, the spores *germinate*[2], the bacteria actively grow in the food, and the toxin is produced. If the contaminated food is eaten without sufficient heat treatment[3] to destroy the toxin, severe illness and in many instances death will occur.

To further complicate the problem, there are six known types of *C. botulinum*. These are differentiated by the type of toxin[4] produced.

The six types are:

A—toxin associated with human illness. This is the most common cause of botulism in the United States.

B—toxin associated with human illness. Type B is found more often than type A in most soils of the world.

C—toxin associated with outbreaks in waterfowl, turkeys, cattle, mink, and other animals.

D—toxin responsible for forage poisoning of cattle. This type is most common in South Africa.

E—toxin associated with human illness. This is usually the cause in outbreaks attributed to fish, fish products, and aquatic environment.

F—toxin associated with human illness. This is relatively rare, only recently isolated and identified.

Occurrence of Botulism

In the November 1971 issue of Family Health magazine in an article entitled, "Stop Worrying about Canned Foods," the author points out that the chance of being killed by lightning is 100 times greater than that of being poisoned by commercially-canned foods (3). This statement helps to point out how infrequent outbreaks of botulism really are.

In the 70 years from 1899 to 1969, there were 659 outbreaks of botulism in this country involving 1,696 individuals of which 952 died, for a mortality rate of 56 percent (8, 9, 10). The sources of the foods involved in these 659 outbreaks are listed in table 1. The information shows that 71.8 percent of the outbreaks in the 70-year period were caused by home-canned food. Less than 10 percent were attributed to commercially-processed or canned food and the majority of these, 41 of 62, occurred before 1930. That was a time when factors causing botulism and methods of preventing outbreaks were not fully understood. Nine of the 11 outbreaks during 1960-69 caused by commercially-processed food were related to smoked fish, which previously had not been identified as a possible cause of botulism. The other two were caused by canned tuna and canned liver paste.

Statistics indicate that the occurrence of botulism is decreasing. Reported outbreaks of other food-borne diseases, such as salmonellosis, staphylococcal food poisoning, and *Clostridium perfringens* food poisoning, are increasing.

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[2] A bacterial *spore* is an inactive form of the cell and must *germinate* to become a *vegetative* or actively growing cell. Germination is the process involved when a spore changes into a vegetative cell.

[3] Botulinal toxins are destroyed by a heat treatment of 176° F. for 10 minutes or at boiling temperatures for a few minutes (12).

[4] A *toxin* is a poisonous substance produced by certain micro-organisms. An antitoxin is a substance produced by man or animal that has the ability to neutralize the toxin.

Methods for preventing botulism outbreaks have been documented and understood for many years. Yet, each year, several small outbreaks occur. These few outbreaks can be eliminated if the consuming public is made more aware of the problem and of proper preventive procedures.

Although few physicians have ever diagnosed a case of botulism in recent years, improved detection methods and more readily available antitoxin have decreased the mortality rate of botulism outbreaks to around 30 percent. The figures in table 2 point this out. The mortality rate for a 19-year period

Table 1. Source of food involved in outbreaks of botulism, 1899-1969*

Source of food	Totals 1899-1969	1899	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	% of total
Home processed	473	1	1	48	77	135	120	50	41	71.8
Commercially processed	62	0	1	14	26	6	1	3	11	9.4
Unknown	124	0	0	8	13	13	13	50	27	18.8
Total	659	1	2	70	116	154	134	103	79	-------

* Compiled from references 8, 9, and 10.

Table 2. Outbreak of botulism by toxin type, 1950-1969*

Toxin Type	Outbreaks	Cases	Deaths	Mortality rate† (percent)
A	22	60	22	38
B	12	25	6	24
E	15	56	24	43
F	1	3	0	0
Unknown	119	255	70	27
Total	169	399	122	31

* Compiled from refereces 8, 9, and 10.

† Mortality rate $= \frac{\text{deaths}}{\text{cases}} \times 100 =$ percent.

Table 3. Food products causing botulism outbreaks, 1899-1969*

Botulinum toxin type	Vegetables	Fruits	Beef†	Pork	Poultry	Fish and fish products	Milk and milk products	Condiments‡	Others§	Total
A	90	22	5	2		6	2	12	8	147
B	21	4	1	1	1	2	2	2		34
E	1					16				17
F			1							1
A&B	10				2			1		13
Total	122	26	7	3	3	24	4	15	8	212

* Table includes only outbreaks in which toxin type was determined, compiled from references 8, 9, and 10.

† Includes one outbreak of Type F in venison, and one outbreak of Type A in mutton.

‡ Includes outbreaks traced to tomato relish, chili peppers, salad dressing, and mushrooms.

§ Includes outbreaks traced to relish, corn, and chicken mash.

(1950-1969) was 31 percent, while the rate was 56 percent during the 70-year period from 1899 to 1969. The death-to-case ratio has been reduced during the past two decades.

Type A botulism is the most prevalent type in this country. Note the 22 outbreaks caused by Type A between 1950 and 1969. Table 3 shows that 147 of 212 outbreaks in the 70-year period 1899-1969 were caused by Type A. This type appears to be more closely associated with vegetables; table 3 indicates that 90 of the 147 Type A outbreaks were associated with vegetables.

Foods Involved

The major type of food involved in botulism outbreaks, as we have seen, are vegetables. Of the 212 botulism outbreaks shown in table 3, 122 were associated with vegetables. Fruits are second with 26 outbreaks, followed by fish, condiments, beef, milk, pork, and poultry. In almost every instance, the foods involved had been canned or processed in some manner, stored for some time, and then consumed.

There are many facets involved in this problem; some will be developed in later sections. But, the major cause of botulism outbreaks is *improperly* processed home-canned food products. Prevention is simple; follow proper techniques when canning food in the home.

The toxin or poison produced by *Clostridium botulinum* has one characteristic that affects the foods involved and may influence the occurrence of outbreaks. This toxin is readily destroyed by heat, that is, it is *heat-liable.* Bringing food to boiling temperatures and holding it at that temperature for a few minutes will inactivate or destroy the toxin (11, 12), rendering it harmless and the food safe to eat. A good rule to follow is always boil home-canned vegetables and *never* taste home-canned vegetables before cooking them, particularly if the vegetables in the container, when opened, have a bad smell, bubble, or look different. Food canned in the home under proper conditions for the type of food involved will be safe to eat. Problems only develop when improper canning techniques are used. Commercially-canned products are safe to eat if neither end of the can is bulged and if the product appears normal and has a normal odor. Commercial food canning companies in the United States design their process so that requirements are met that are far in excess of that necessary to destroy the spores of *Clostridium botulinum.* These procedures will be discussed more fully in the section on prevention and control.

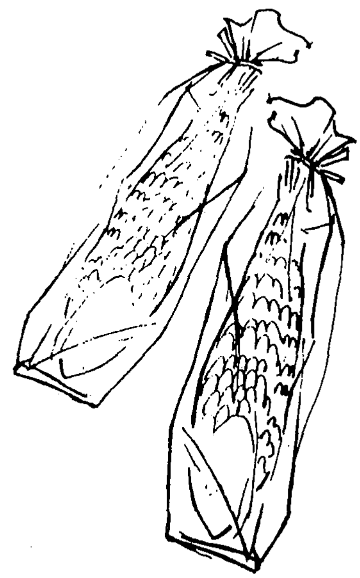
Conditions Needed for Outbreak

In order for an outbreak of botulism to occur, several conditions are necessary:

1. The micro-organism *Clostridium botulinum* must be in the food.
2. The food is canned or processed in some way.
3. Inadequate processing or heating permits spore survival.
4. Conditions after processing are such that the spores can germinate and the vegetative cells can grow and produce toxin.
5. The food is not heated sufficiently before eating to inactivate the toxin.
6. The poisonous food is eaten.

Clostridium botulinum grows anaerobically, that is, it grows best when there is no air or free oxygen present in its environment. Accordingly, when food is heated, as in canning, the air is driven out by the process. Anaerobic conditions are established when the container is sealed. The absence of air in the system prevents the growth of other types of micro-organisms that normally may spoil and thus render the food aesthetically unacceptable for consumption. One example of this type of problem is the outbreak of botulism caused by smoked fish in 1963 (1).

Although there were many contributing factors to this outbreak, many scientists thought one of the chief causes was the vacuum packaging of the smoked fish in pliofilm bags. These films keep air away from the product and essentially maintain anaerobic conditions. Under these conditions normal spoilage micro-organisms, such as molds and some bacteria, were unable to grow and produce typical spoilage characteristics, such as mold spots, odors, or slime. Because in many cases *C. botulinum* does not bring about these spoilage changes when growing, it was impossible to detect spoilage by the appearance and smell of the product. A package that was designed to solve one problem really created another one. Smoked fish is no longer sold in a vacuum-sealed package.



Other outbreaks that will be described later will illustrate other conditions that have caused botulism outbreaks.

Factors Affecting Growth and Toxin Production

Perhaps the most perplexing facet of the botulism problem is the many factors that seem to have some influence on the growth and toxin production of *C. botulinum*. As has been stated, we presently know of six types of toxin associated with this organism. At this time, four of the six, A, B, E, and F, have been associated with human illness. Of these four, A, B, and E are the most common. Therefore, comments concerning growth will be directed at these three types. Closely related to growth of this organism is toxin production that depends upon the ability of the cells of *C. botulinum* to grow in a food and to distintegrate and release toxin. Therefore, the factors that influence spore germination, vegetative cell growth, and subsequently toxin production are of concern. These factors would include the composition of the food, moisture content, pH[5], availability of oxygen, salt content, and time and temperature of storage. It is the combination of these factors that determines whether growth takes place (7).

Acid is one of the primary factors influencing the growth of *C. botulinum* and is utilized as a control. Research and experience show that a pH near neutral favors the growth of this organism, while at a pH of 4.5 or lower, growth is inhibited. The pH of a food also has an influence on the amount of heat necessary to kill the spores of *C. botulinum*. Therefore, a classification of foods has developed based upon their acid content. This content is used in establishing the heat treatment necessary to achieve preservation and safety when canning food. In general the classification is:

Low-acid foods—pH above 5.3. Such foods as peas, corn, lima beans, meats, fish, and poultry are in this group.

Medium-acid foods—pH between 5.3 and 4.5. Foods such as spinach, asparagus, beets, and pumpkin are usually in this range.

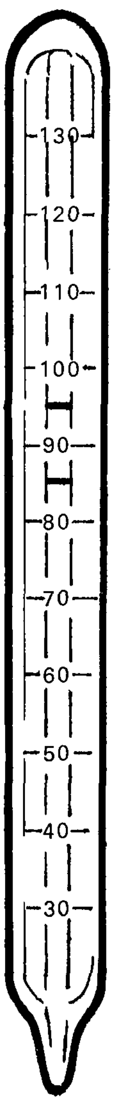
Acid foods—pH between 4.5 and 3.7. Tomatoes, pears, and red cabbage are examples of foods with this acidity.

High-acid foods—pH below 3.7. Sauerkraut and berries are examples of high acid foods.

[5] Technically, pH is defined as the negative log of the hydrogen ion concentration. If we apply this definition to food, it means a measure of the amount of acid or alkali in the food. The scale ranges from 0 to 14 with 7 considered neutral, 0 to 7 acidic, and 7 to 14 alkaline. The closer the pH value is to 0, the more acid in the food. The nearer the pH value is to 14, the more alkali in the food.

The important separation in this classification is between medium-acid foods and acid foods at pH 4.6. Foods with pH values above 4.6 require pressure processing (temperatures above boiling) while foods with pH values below 4.6 usually can be successfully preserved at boiling temperatures. This will be discussed further in the section on prevention and control.

A second important factor affecting the growth and toxin production of *C. botulinum* is temperature. Different strains vary, but in general Types A and B grow best close to 95° F. but can grow at temperatures as low as 50° F. and as high as 118° F. Type E has been shown to grow and produce toxin at 38° F., but its best growth is achieved at 86° F. and the highest temperature its growth has been observed at is 113° F. Because toxin production is associated with growth, it is obvious that the most toxin will be produced at temperatures where the organism grows best. At the low and high extremes of the growth temperature ranges, toxin production lessens as growth is slower (7, 12).



Another condition affecting the growth of *C. botulinum* is the presence of oxygen. These organisms are "obligate anaerobes," which means they cannot grow if air or free oxygen is present in their microenvironment. The microenvironment consists of the area immediately adjacent to tthe microbial cell that has a direct relationship on the growth of the micro-organism. This area is so small that it is not readily observed. It is possible to have conditions develop in a food system whereby it appears to be highly aerobic, that is, having lots of air available, but in reality there are areas where no air is present and anaerobic organisms can develop. Anaerobic conditions develop when food is canned. Heating the food in the container drives out the air. The container is sealed and anaerobic conditions are created. If the food is not heated enough to kill the spores of *C. botulinum*, the spores germinate and grow during subsequent storage of the food. In the manufacture and preservation of other types of food, anaerobic conditions also can develop. Smoked fish can develop anaerobic conditions in the visceral cavity and under the skin. The interior of sausage may become anaerobic during the preservation process. In instances where these conditions may develop in a semiperishable food, such as smoked fish, *C. botulinum* growth is prevented by low temperature storage of the food.

Clostridium botulinum can grow in many types of food, as was shown in table 3. Growth of this organism in some food may result in a foul, rancid odor that would result in the food being rejected. However, growth in other types of foods may result in little if any change in odor and appearance and these foods will be just as toxic. The advisable thing to do is reject all foods, raw or canned, that show signs of spoilage and never use any canned foods that exhibit any signs of pressure in the container. A good motto to follow is "When in doubt, throw it out."

Toxins and Antitoxins

Botulinal toxins are proteins. A great deal of research has been done over the years to characterize these toxins. The protein has been purified and crystallized and as was mentioned earlier is a very powerful toxin. It is absorbed mostly in the small intestine and paralyzes the involuntary muscles of the body. The six botulinal toxins are antigenic, that is they bring about the formation of neutralizing substances when they are introduced into human or animal blood. These neutralizing substances are called antibodies, or when used with reference to a toxin, they are called antitoxins. The antitoxins are used in the treatment of those unfortunate people who may have been poisoned by botulinum toxin. If the antitoxin is used sufficiently early in the course of the disease, the treatment is usually successful (7, 12).

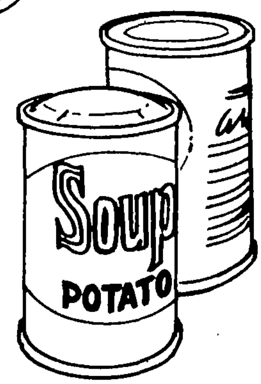
Reported Outbreaks

A look at some documented botulism outbreaks between 1963 and 1971 illustrates some factors causing botulism as well as how these outbreaks could have been prevented.

An interesting phenomenon associated with outbreaks of botulism is the widespread publicity involved when a commercially-processed or canned food is incriminated. This publicity usually is not given to outbreaks involving home-canned or processed foods or even to outbreaks of other types of food-borne disease such as salmonellosis, staphylococcal food poisoning, or *Clostridium perfringens* food-borne illness, even though the other types of food-borne outbreaks will involve more people. The incidence of outbreaks of botulism is very low in comparison with the types of food-borne disease listed above. A look at several recent outbreaks of botulism and their cause may lend some insight into methods of preventing these outbreaks.

Commercially-canned Foods

Perhaps the most notorious outbreak of botulism in 1971 involved a can of vichyssoise that had been commercially canned by a relatively small company. A portion of the soup was eaten at an evening meal by a man and his wife. The soup tasted spoiled so they ate only a small portion and threw the rest away. The following day the man became ill and was hospitalized. He died that evening. Botulism was diagnosed the next day when the woman was hospitalized and she was successfully treated with antitoxin (5). Investigation of the outbreak by regulatory agencies and the manufacturer of the soup revealed that one batch of 460 cans of the soup had not been processed properly, resulting in spoilage and consequently botulism in this particular batch (13, 14, 15). Ironically, vichyssoise is a potato soup that is eaten *cold*. This particular outbreak, in addition to the death, was disastrous to the soup manufacturer. The recall of not only the lot of underprocessed soup but all the soup manufactured by this company (which subsequently was shown to be free of any botulinum toxin by the National Canners Association), plus the adverse publicity the company received in the news media, resulted in the company filing bankruptcy (13, 14, 15). The underprocessing of that one batch proved to be a costly mistake. Obviously, the outbreak could have been prevented with proper processing, but it also could have been prevented if the consumer had realized that food from a swollen can should never, under any circumstances, be eaten. The foul odor should have been a second clue to the fact that there was something wrong with the soup and that it should not have been eaten. A good rule to follow is: **Never eat or even taste food from a swollen container or food that is foamy or has a bad odor from a swollen, sealed container.**



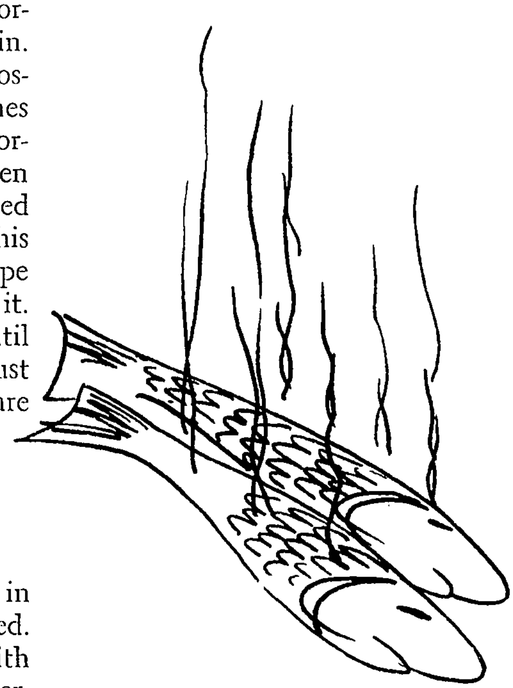
Contrast the results of the above outbreak with the discovery of botulinum toxin in soup during a routine quality check by a large soup manufacturer; thousands of cans of soup were involved, yet there was not one case or outbreak of botulism associated with this particular brand of soup. The company recalled all of this product from the market at a cost of millions of dollars. Why did this occur? Why should a company that has been in existence for more than 100 years and that has produced millions of cans of soup without incidence all of a sudden have a problem? The answers to these questions point out the complexity of the problem and make one realize how important proper processing is and how easy it can be to make a small mistake or miscalculation that can create a serious problem.

Investigations by this company showed that the cause of the incident was the combination of several unusual conditions all of which happened at the same time. The contamination with botulinum toxin occurred in the soup processed in one plant with a new technique. This process, under normal conditions, was more than adequate to provide a safe process, but the process became inadequate when the conditions given below occurred simultaneously. The content of the cans was more viscous (thicker) than normal. The cans were overfilled, and some of the dry ingredients used in the manufacture of the soup were not completely rehydrated (16). Each of these factors influence how fast the heat penetrates into the can and thus has an effect on the heat destruction of the micro-organisms present in the food. The important fact to remember about this occurrence is that no illnesses resulted and that the company, after finding the contaminated product, did very rapidly and successfully remove all implicated cans, therefore preventing any possible public health problem.

In 1963, there were two outbreaks associated with commercially-canned food, one involved canned tunafish, the other canned liver paste. The canned tuna outbreak had three cases and two deaths. In this particular outbreak, improper processing was not the cause, but it was found that the cans were faulty at the seams and the product was contaminated with *C. botulinum* Type E spores after processing. The commercially-canned liver paste caused two outbreaks, one in New York, the other in Montreal, Canada. In the New York outbreak, there were two cases with no deaths, whereas in the Canadian outbreak there were two cases with one death. The product had been canned in Canada and investigation subsequent to the two outbreaks indicated the liver paste had been grossly underprocessed, resulting in the contaminated product (1).

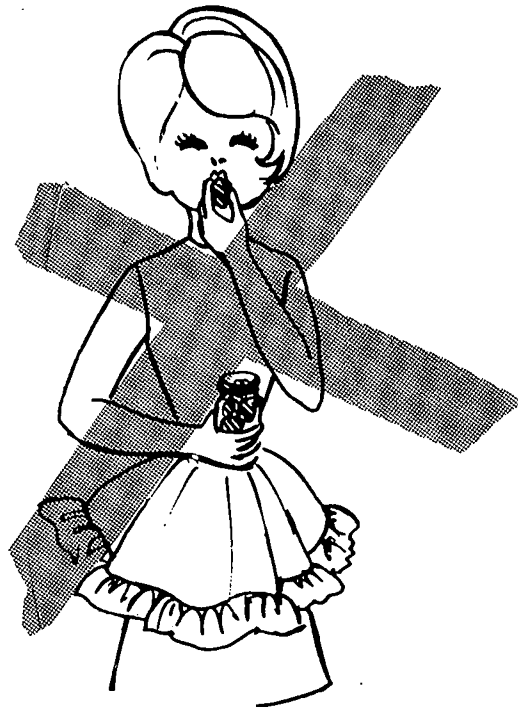
Commercially-processed Foods

Another series of outbreaks in 1963 involved commercially-processed smoked fish. There were 19 cases with seven deaths from two outbreaks. In one of these outbreaks, two people purchased a large smoked whitefish and put it in the back of their car. It was warm and no ice was used to keep the fish cold. This proved to be a fatal mistake for these two people; they subsequently died from botulinum Type E toxin shortly after eating a portion of the smoked fish. The other outbreak also involved Type E toxin. Prior to these 1963 outbreaks, smoked fish was not considered to be a possible source of botulism. As a result of these outbreaks, specific guidelines and regulations now exist for smoking fish and subsequent handling and storage of the smoked fish. Minnesota regulations require that the fish, when being smoked, be heated to an internal temperature of 180° F. and maintained at that temperature for no less than 30 minutes. Research has shown that this time-temperature relationship is sufficient to destroy any *C. botulinum* Type E spores or cells that might be present. Packaging film must have holes in it. In addition, smoked fish must be stored at 40° F. or lower after smoking until consumption. Some states have requirements whereby the smoked fish must be frozen and sold for consumption in that state. Both of these measures are adequate to prevent and control Type E botulism in smoked fish.



Home-canned Foods

The last reported outbreak of botulism caused by home-canned foods in 1971 occurred in Bakersfield, California. A family of seven was involved. About 36 hours after eating a home-prepared dinner, five of seven were ill with symptoms diagnosed as those of botulism. One of the five died 3 days later. Home-prepared chili sauce was implicated as the cause of the illness. The sauce had been made from a bottle of red and green chili peppers that had been home canned approximately 6 weeks earlier using carrots, garlic, and onions. No acid, such as vinegar, had been added to the chili peppers and they were inadequately heated. The canned peppers, when opened prior to use in the chili sauce, were foamy and had a foul smell, but were used anyway. Four other bottles had been prepared at the same time, one had been consumed some weeks earlier without problem and one had been discarded because it looked spoiled. Laboratory studies revealed botulinum toxin Type A in the peppers used to prepare the chili sauce and the toxin was found in the blood from one of the patients. This confirmed the source of the problem (2). How easily this outbreak could have been avoided! Proper techniques, when the peppers were canned, would have prevented the outbreak. The foam and odor of the peppers, when they were opened, should have been enough evidence that the peppers were spoiled and they should have been destroyed right away rather than used and eaten.



Home-canned peppers were the cause of another outbreak in 1971. A man and his wife became ill the day after eating home-canned peppers. Subsequently, the woman died and the man eventually recovered. A neighbor who had eaten some of the peppers also became ill and she recovered. Botulinum toxin Type B was isolated from the leftover peppers. The neighbor indicated that the peppers had a "bad taste" and that she had only taken a couple of bites (17). These outbreaks point out again how important it is to use proper canning techniques when preserving food at home and that one should never eat or taste canned food that has a bad odor or looks spoiled.

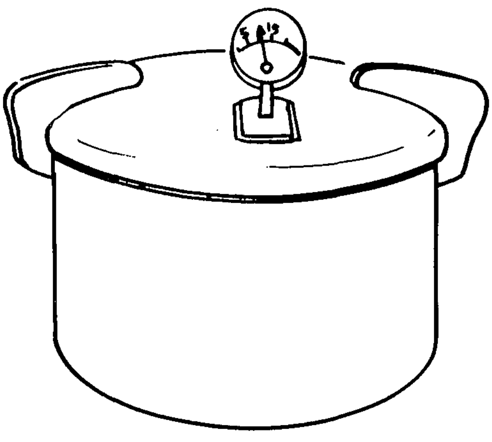
The habit of tasting home-canned vegetables before they are cooked almost cost one woman her life in South Bend, Indiana (18). The woman became ill one day and became progressively sicker as the days went on. Finally, 5 days after her initial symptoms appeared, botulism was considered and antitoxin therapy started. Her condition had been diagnosed as viral encephalitis, idiosyncratic reaction to prochloroperazine, and myasthenia gravis. She recovered a full 8 days after botulinum antitoxin therapy was started. The interesting part of this outbreak was that the woman shared all her meals with two other individuals, neither of whom became ill. They quite often consumed home-canned vegetables that were fully cooked at their meals. But the woman had the habit of tasting the home-canned vegetables prior to cooking and this probably explains why she became ill and none of the others did. This case also points out how difficult it is to diagnose botulism. Most physicians probably do not see a case of botulism in a lifetime of practice, simply because they occur very infrequently. This results in the misdiagnoses. The National Center for Disease Control, Atlanta, Georgia, periodically distributes to physicians and other interested individuals information concerning the diagnosis of botulism and the use of and availability of botulinum antitoxin in an effort to aid in the early diagnosis and treatment of botulism.

A late evening snack of eggs, onions, and mushrooms proved to be a fatal one for a man in Chicago (19). Approximately 10 hours later, he became ill and was hospitalized. About 48 hours after he had eaten the late evening snack, botulism was diagnosed and antitoxin therapy was started. Following treatment, he showed little improvement and 35 hours later he died. The fatal food in this outbreak was shown to be the home-canned mushrooms. The mushrooms were observed to have a foul odor. Botulinum toxin Type A was found in the leftover mushrooms and in the patient's serum. The mushrooms had been gathered locally and canned 5 months earlier. The canning procedure involved washing, slicing, and boiling at atmospheric pressure for 4 hours. While still hot, the mushrooms were poured into jars, sealed, and stored. Mushrooms are low-acid foods; is this the proper canning technique? NO! Low-acid foods should never under any circumstance be canned by boiling; they must be canned in a pressure cooker.

For some reason, the year 1963 was exceptional in that there were 46 cases of botulism associated with 12 outbreaks and causing 16 deaths (1). The four outbreaks associated with commercially-processed or canned food were described above.

Other outbreaks in 1963 that were caused by home-canned foods include one involving marinated mushrooms with six cases and one death. Green beans were implicated in three outbreaks with six cases and two deaths. In each outbreak, the beans had been processed at boiling temperatures and exhibited signs of spoilage when opened—two "no-no's" when canning and consuming green beans (1).

Prevention and Control



As complex as this problem appears to be, prevention and control are relatively easy. The primary control technique is the use of processing techniques known to destroy *C. botulinum* spores when canning food or preserving food or preserving food in some manner. The second control point occurs when the preserved food is to be consumed. The cardinal rule is never use canned food that shows any signs of spoilage. Examine the containers closely before opening them. Bulging can ends and jar lids usually indicate spoilage. When you open the containers, check for off-odors, froth, foam, or mold. If any of these signs of spoilage are evident, do not use the food. In addition, low-acid home-canned vegetables should be boiled before tasting. If it becomes necessary to dispose of home-canned foods, do it in such a way that there is no chance that it will be eaten by humans or animals.

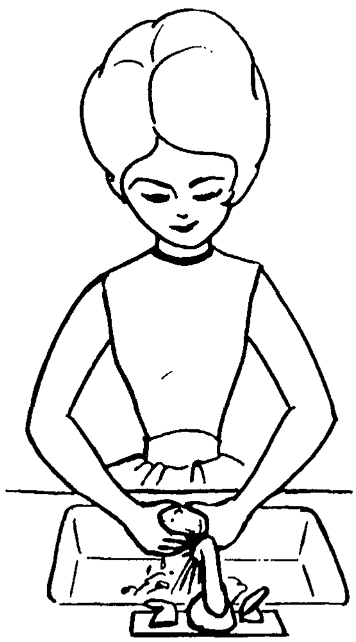
Correct processing methods for canning foods are established after studying the various factors that influence the heat destruction of the *C. botulinum* spores in the food. These factors generally are associated with the rate of heat transfer or penetration into the food container. Such things as container size, thickness or viscosity, solids content, initial temperature of the food, container material, and number of spores in the food must be considered when developing a canning process. The manner in which these processes are developed are beyond the scope of this bulletin; fortunately, these processes were developed many years ago and are still applicable today. If any of the components listed above change, then the process must be changed to account for the variation in the canned food.

Commercial processes used to can foods are developed and designed to provide sufficient heat treatment to destroy the spores of *C. botulinum*. In most instances, processes used are in excess of the minimum requirement necessary to achieve food safety. Spore-forming bacteria that are more heat resistant than *C. botulinum* often are used to establish the time and temperature of treatments necessary to achieve sterilization. In most instances, minimal heat processes for all types of canned foods have been developed and are available from agencies, such as the National Canners Association. If you are interested in producing canned food, it is essential that your process is safe. This can be determined by checking with your local regulatory agency. In Minnesota, the Department of Agriculture is resonsible for inspection and regulation of commercial canning.

Unfortunately, there is no regulatory agency responsible for the canning of food in the home. The correctness of the procedure is dependent upon the knowledge of the homemaker. Fortunately, there are many good books, pamphlets, folders, and bulletins readily available to the homemaker, all of which will give proper canning techniques. An excellent publication available from the county extension offices in Minnesota is Home Canning of Fruits and Vegetables, Extension Folder 100, by Grace Brill.

Some of the information from this folder will be presented here. But, if you wish to successfully home can foods, it is essential that you obtain more complete information.

Home Canning of Fruits and Vegetables (a summary)



POINTS TO REMEMBER

The cleaner your product, the more effective your canning process. Wash all vegetables well. Handle them gently to prevent bruising.

Spoilage organisms may develop on utensils as you use them, especially if the product is starchy or milky. When you can vegetables with these characteristics (corn, for instance), wash, rinse, and scald utensils and work surfaces between batches.

Salt in small amounts adds flavor but does not help in the preservation process. Never add sugar when canning vegetables. Both salt and sugar can easily be added when the vegetable is reheated for serving.

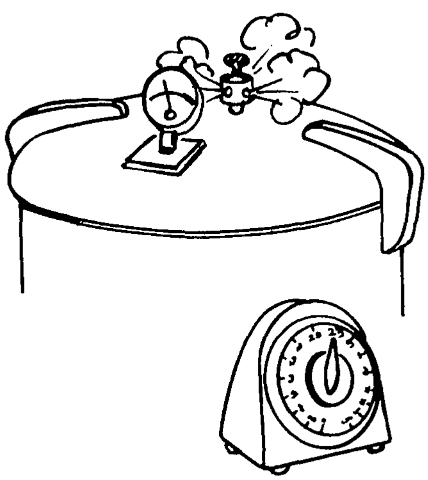
Canning powders or drugs such as boric acid and aspirin should never be used in canning. Canning powders are ineffective and unreliable as preservatives except in large amounts, which may be harmful and will certainly change the flavor of your product. Boric acid and aspirin are drugs, not preservatives.

Heat is the only dependable preservative, but some foods need more heat than others. While foods containing acid (fruit, tomatoes, pickled vegetables) may be processed in boiling water, temperatures hotter than boiling are required for all other canned products (meat, fish, vegetables). Use a pressure canner to get the temperature more than 212° F.

PRELIMINARY DETAILS

Plant or purchase vegetables or fruit varieties recommended for canning.

Assemble and wash equipment and containers before gathering fruits and vegetables. Examine jars and discard those with nicks, cracks, rough edges, or other irregularities. Use new rubber jar rings or new metal lids and standard canning jars.



Gather products early, when they are at their peak of quality, and gather only as much as you can handle within 2 or 3 hours.

Prepare foods as you would for the table. Keep them cold until you are ready to begin the actual canning.

HOW TO PACK GLASS JARS

(When using tin, follow the manufacturer's instructions for filling and sealing. Follow time and pressure tables in this bulletin.)

Scald the washed jars and keep them hot. If salt is used, be sure to put it into the jar before the vegetable. Use ½ teaspoonful for each pint.

Use one of two methods for packing fruits or vegetables: hot pack or raw pack. More food can be packed into one jar when hot pack is used and this method is best for foods that tend to discolor during canning. Packing products such as green beans raw helps to retain flavor and food value. Try both ways and make your own choice.

Before applying lids, wipe off the rims of your jars with a piece of muslin dipped in hot water.

Keep jars hot after filling them by placing them in either a boiling-water-bath canner or a steam-pressure canner. Process, following timetable 1 or 2 at the end of this bulletin.

PROCESSING METHODS

Pressure canner method—Get your pressure canner in good condition before the canning season starts. Have pressure gage and safety valve tested, all parts cleaned, and broken or missing parts replaced.

Order new parts from manufacturer or hardware dealer. Gages, safety valves, and petcocks are usually interchangeable among different makes of pressure cookers, but make sure before you buy.

Follow the manufacturer's instructions for opening and closing the pressure canner. Follow pressure and timetables given in this bulletin.

Have 2 or 3 inches of boiling water in the pressure canner. Stand the jars on a rack so they are not touching each other or the sides of the canner. Fasten lid to pressure canner and open the petcock.

Turn heat on until steam flows from petcock in a steady stream (10 minutes or more after it first appears). At first a mixture of steam and air will be released as a white vapor or cloud. When all the air is driven out, the steam will become nearly invisible about 1 to 2 inches from the petcock. It is then time to close the petcock.

Raise pressure rapidly to 2 pounds less than required, reduce heat, and bring up the last 2 pounds slowly to avoid overpressure. Fluctuating pressure is one cause of liquid loss, so hold the pressure at 10 pounds.

When processing time is up, remove canner from heat and allow it to cool. When the pressure registers zero, wait 1 or 2 minutes, then slowly open the petcock. Unfasten the cover and tilt the far side up so that steam escapes away from you. Remove each jar with jar tongs or lift them out in the wire basket.

If the petcock is not open a few minutes after the pressure has dropped to zero, a vacuum may form inside the cooker. This may draw liquid from jars and seal the lid to the canner.

Cooling the jars—Place jars upright on a perfectly dry, nonmetallic surface (towel, board, or newspapers may be used) spread for free air circulation.

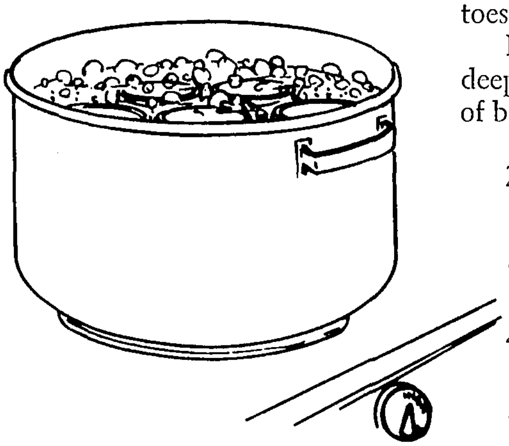
Test seals when jars are thoroughly cool. Wash, dry, and label. Store jars where it is dry and cool but never subject them to freezing. Test jars with flat metal lid by tapping the center of the lid with a spoon. A clear, ringing sound means a good seal. A dull note does not always mean a poor seal; if there is no leakage, store the jar and watch for signs of spoilage.

Pressure saucepan method—The pressure saucepan is made especially for cooking, but it can be used for canning small quantities of food if (1) it has a gage or indicator that registers 10 pounds accurately, and (2) it is large enough to hold pint jars on a rack when its cover is locked in place.

Because a pressure saucepan heats and cools rapidly, its canning time is longer (about 20 min.) than for a large pressure canner (see table).

Prepare jars and process foods as with a pressure canner. When through processing, drop pressure naturally. Do not water-cool to reduce pressure.

Boiling-water-bath method—(Use only for acid products such as fruits, tomatoes, and pickled vegetables.)



For boiling-water-bath, use a utensil that has a close-fitting cover and is deep enough to allow jars standing on rack to be covered with at least 1 inch of boiling water.

1. Use pressure canner method in packing jars and adjusting jar lids.
2. Have the water-bath ready. Lower the jars quickly. If water evaporates, add boiling water to keep the level an inch or more over the jar tops. Count time when water begins to boil; keep at rolling boil.
3. When processing time is completed, remove jars. Don't disturb lids on self-seal jars, but tighten closures at once on all others.
4. Set the jars right side up on a dry surface, spacing them for free air circulation.
5. When cold, test for seal, remove screwbands (if self-seal closure), label, and store where it is cool and dry.

Use of pressure canner for processing fruit—Your pressure canner also may be used as a water-bath canner. Fill canner with enough water to reach shoulders of the jars, and fasten cover. When live steam pours steadily from the open vent, start counting time. The gage may register from 0-1 pound pressure. Leave vent open and process for the same time as for the boiling-water bath.

Commercial canning of food—The processes presented in this bulletin are designed for home canning of vegetables and fruits using a home pressure canner or boiling-water bath. With larger containers or different types of canning vessels, these recommended times and temperatures may be inadequate for a safe process. To establish a safe commercial process, consult the National Canners Association or your local regulatory agency.

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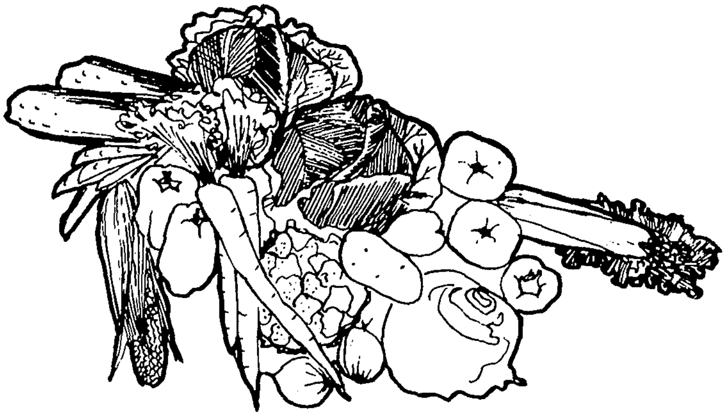

Timetable 1—Processing low-acid vegetables

PRODUCT	Work rapidly. Raw pack or hot pack foods following directions, adding if desired ½ teaspoon salt for pints and 1 teaspoon for quarts. Place jars on rack in pressure cooker containing 2 to 3 inches of boiling water. Fasten canner cover securely. Let steam escape 10 minutes or more before closing petcock.	USE 10-POUND PRESSURE: PRESSURE CANNER, Glass jars, Pints	Glass jars, Quarts	Tin cans, #2	Tin cans, #2½	PRESSURE SAUCEPAN, Glass jars, Pints
		min.	min.	min.	min.	min.
Asparagus	**Raw pack**—Wash asparagus; trim off scales and tough ends and wash again. Cut in 1-inch pieces. Pack asparagus tightly as possible without crushing to ½ inch of top. Cover with boiling water leaving ½ inch at top.	25	30	20*	20*	45
	Hot pack—prepare as for raw pack; then cover with boiling water. Boil 2 or 3 minutes. Pack asparagus loosely to ½ inch of top. Cover with boiling water leaving ½ inch at top.	25	30	20*	20*	45
Beans, dry with tomato or molasses sauce	**Hot pack**—Sort and wash dry beans. Cover with boiling water; boil 2 minutes, remove from heat and let soak 1 hour. Heat to boiling and drain, saving liquid for sauce. Fill jars ¾ full with hot beans. Add small piece of salt pork, ham, or bacon. Fill to ½ inch of top with hot tomato or molasses sauce.	65	75	65*	75*	85
Beans, fresh lima	**Raw pack**—Shell and wash beans. Pack loosely small type to 1 inch of top of jar for pints and 1½ inches for quarts; for large beans fill to ¾ inch of top for pints and 1¼ inches for quarts. Fill jars to top with boiling water.	40	50	40*	40*	60
	Hot pack—Shell the beans, then cover with boiling water, and bring to boil. Pack beans loosely in jar to 1 inch of top. Cover with boiling water, leaving 1 inch at top.	40	50	40*	40*	60
Beans, snap	**Raw pack**—Wash beans. Trim ends and cut into 1 inch pieces. Pack tightly in jars to ½ inch of top. Cover with boiling water, leaving ½ inch at top.	20	25	25*	30*	40
	Hot pack—Prepare as for raw pack beans. Then cover with boiling water and boil 5 minutes. Pack beans in jars loosely to ½ inch of top. Cover with boiling-hot cooking liquid and water, leaving ½ inch at top.	20	25	25*	30*	40
Beets	**Hot pack**—Sort beets for size. Cut off tops, leaving 1 inch stem, also root; and wash. Boil until skins slip easily. Skin, trim, cut, and pack into jars to ½ inch of top. Cover with boiling water, leaving ½ inch at top.	30	35	30‡	30‡	50
Carrots	**Raw pack**—Wash and scrape carrots. Slice, dice, or leave whole. Pack tightly in jars to 1 inch of top. Fill to top with boiling water.	25	30	25*	30*	45
	Hot pack—Prepare as for raw pack, then cover with boiling water and bring to boil. Pack carrots in jars to ½ inch of top. Cover with boiling-hot cooking liquid and water, leaving ½ inch at top.	25	30	20*	25*	45
Corn—cream style	**Raw pack**—Husk corn and remove silk. Wash. Cut corn from cob at about the center of the kernel and scrape cobs. Pack corn loosely in pint jars to 1 inch of top. Fill to top with boiling water.	95		105†		115
	Hot pack—Prepare as for raw pack. Add 1 pint boiling water to each quart of corn. Heat to boiling. Pack hot corn to 1 inch of top.	85		105†		105
Corn—whole kernel	**Raw Pack**—Husk corn and remove silk. Wash. Cut from cob at about 2/3 the depth of kernel. Pack corn loosely to 1 inch of top and fill to top with boiling water.	55	85§	60†	60†	75
	Hot pack—Prepare as for raw pack. To each quart of corn add 1 pint of boiling water. Heat to boiling. Pack loosely to 1 inch of top with mixture of corn and liquid.	55	85§	60†	60†	75
Peas, green	**Raw pack**—Shell and wash peas. Pack peas loosely in jars to 1 inch of top. Cover with boiling water, leaving 1 inch at top.	40	40	30*	35*	60
	Hot pack—Prepare as for raw pack. Cover with boiling water and bring to boil. Pack peas loosely in jars to 1 inch of top. Cover with boiling water, leaving 1 inch at top.	40	40	30*	35*	60
Pumpkin or winter squash cubed	**Hot pack**—Wash pumpkin or winter squash, remove seeds, and pare. Cut into 1 inch cubes. Add just enough water to cover. Bring to boil. Pack cubes in jars to ½ inch of top. Cover with hot cooking liquid and water, leaving ½ inch at top.	55	90	50‡	75‡	75
Pumpkin or winter squash strained	**Hot pack**—Wash pumpkin or winter squash, remove seeds, and pare. Cut into 1 inch cubes. Steam until tender (about 25 minutes). Put through food mill or strainer. Simmer until heated. Pack hot in jars to ½ inch of top.	65	80	75‡	90‡	85
Spinach and other greens	**Hot pack**—Pick over and wash thoroughly. Cut out tough stems and midribs. Place about 2½ pounds of spinach in cheesecloth bag and steam about 10 minutes or until well wilted. Pack loosely to ½ inch of top. Cover with boiling water, leaving ½ inch at top.	70	90	65*	75*	90

*** Use plain tin.** † Use C enamel cans. ‡ Use R or sanitary enamel. § The State Department of Agriculture recommends all corn be canned in pints rather than quarts since processing time required for quarts tends to darken it.

Timetable 2—Processing fruits, tomatoes, pickled vegetables in boiling-water bath

PRODUCT	Raw pack or hot pack foods following directions. Put filled glass jars into canner containing hot or boiling water: for raw pack have water in canner hot but not boiling; for all other packs have water boiling. Add boiling water to bring water 1 or 2 inches over tops of jars but don't pour boiling water directly on glass jars. Put on cover of canner. Count processing time when water in canner comes to a rolling boil.	GLASS JARS		TIN CANS	
		Pts.	Qts.	# 2	# 2½
		min.	min.	min.	min.
Apples	**Hot pack**—1. Pare, core, cut into pieces. To keep from darkening, place in water containing 2 tablespoons each of salt and vinegar per gallon. Drain, then boil 5 minutes in thin sirup or water. Pack apples in jars to ½ inch of top. Cover with hot sirup or water, leaving ½ inch at top.	15	20	10*	10*
	2. Make applesauce, sweetened or unsweetened; pack hot to ¼ inch of top.	10	10	10*	10*
Beets, pickled	**Hot pack**—Cut off beet tops, leaving 1 inch of stem and root. Wash beets, cover with boiling water and cook until tender. Remove skins and slice. For pickling sirup use 2 cups vinegar to 2 cups sugar. Heat to boiling. Pack beets in jars to ½ inch of top. Add ½ teaspoon salt to pints, 1 teaspoon to quarts. Cover with boiling sirup, leaving ½ inch at top.	30	30		
Berries, except strawberries	**Raw pack**—Wash berries and drain. Fill jars to ½ inch of top, shaking berries down gently. Cover with boiling sirup (thin or medium recommended) leaving ½ inch at top.	10	15	15†	20†
	Hot pack—Wash berries and drain well. Add ½ cup sugar to each quart fruit. Cover pan and bring to boil. Pack berries to ½ inch of top.	10	15	15†	20†
Cherries	**Raw pack**—Wash; remove pits if desired. Fill jars to ½ inch of top, shaking cherries down gently. Cover with boiling sirup (thin or medium) leaving ½ inch at top.	20	25	20†	25†
	Hot pack—Wash; remove pits if desired. Add ½ cup sugar to each quart of fruit. Add a little water to unpitted cherries. Cover pan and bring to boil. Pack hot to ½ inch of top.	10	15	15†	20†
Fruit juices	**Hot pack**—Wash; remove pits if desired and crush fruit. Heat to simmering. Strain through cloth bag. Add sugar if desired—about 1 cup to 1 gallon juice. Reheat to simmering and fill jars to top.	10	10	10†	10†
Fruit puree	**Hot pack**—Use sound, ripe fruit. Wash; remove pits if desired. Cut large fruit in pieces. Simmer until soft, add a little water if needed. Put through strainer or food mill. Add sugar to taste. Heat to simmering and pack to ¼ inch of top	10	10	10†	10†
Peaches or apricots	**Raw pack**—Wash peaches or apricots and remove skins. Remove pits. To keep from darkening place in solution (same as apples). Drain, pack fruit in jars to ½ inch of top. Cover with boiling sirup (light or medium) leaving ½ inch at top.	25	30	30*	35*
	Hot pack—Prepare fruit as for raw pack. Heat fruit through in hot sirup. If fruit is very juicy you may heat it with ½ cup of sugar to 1 quart of raw fruit adding no liquid. Pack fruit to ½ inch of top.	20	25	25*	30*
Pears	Peel, cut in halves, and core. Follow directions for peaches either raw pack or hot pack using same timetables.				
Plums	**Raw pack**—Wash. To can whole, prick skins. Freestone varieties may be halved and pitted. Pack fruit in jars to ½ inch of top. Cover with boiling sirup, leaving ½ inch space at top.	20	25	15†	20†
	Hot pack—Prepare as for raw pack. Heat to boiling in sirup or juice. If fruit is very juicy, you may heat it with sugar, adding no liquid. Pack hot fruit to ½ inch of top. Cover with boiling sirup, leaving ½ inch at top.	20	25	15†	20†
Rhubarb	**Hot pack**—Wash and cut into ½ inch pieces. Add ½ cup sugar to each quart rhubarb and let stand to draw out juice. Bring to boiling. Pack hot to ½ inch of top.	10	10	10†	10†
Sauerkraut	**Hot pack**—Heat well-fermented sauerkraut to simmering (185°-210°F.). Pack hot kraut to ½ inch of top. Cover with hot juice, leaving ½ inch at top.	15	20	20*	25*
Tomatoes	**Raw pack**—Use only perfect, ripe tomatoes. Scald just long enough to loosen skins; plunge into cold water. Drain, peel, and core. Leave tomatoes whole or cut in halves or quarters. Pack tomatoes to ½ inch of top, pressing gently to fill spaces. Add ½ teaspoon salt to pints and 1 teaspoon to quarts.	40	50	55*	55*
	Hot pack—Quarter peeled tomatoes. Bring to boil and pack to ½ inch of top. Add salt as for raw packed tomatoes.	35	45	45*	45*
Tomato juice	**Hot pack**—Use ripe, juicy tomatoes. Wash, remove stem ends, cut into pieces. Simmer until softened and put through strainer. Add 1 teaspoon salt to each quart juice. Reheat to just boiling. Fill jars with juice to ¼ inch of top.	35	35	40*	40*

* Use plain tin for apples, apricots, peaches, pears, sauerkraut, and tomatoes.

† Use R enamel cans for berries, cherries, plums, rhubarb.

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